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BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application Number: 09/846,980
Filing Date: April 30, 2001
Appellant(s): STOCKMAN ET AL.

Rachel Leiterman
For Appellant

SUPPLEMENTAL EXAMINER'S ANSWER

This is in response to the appeal brief filed 4/6/2006 appealing from the Office action mailed 8/6/2003.

(1) Real Party in Interest

A statement identifying the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

A statement identifying the related appeals and interferences which will directly affect or be directly affected by or have a bearing on the decision in the pending appeal is contained in the brief.

(3) Status of Claims

The statement of the status of the claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Invention

The summary of invention contained in the brief is correct.

(6) Issues

The appellant's statement of the issues in the brief is correct.

(7) Grouping of Claims

The rejection of claims 1 and 3-60 stand or fall together because appellant's brief does not include a statement that this grouping of claims does not stand or fall together and reasons in support thereof. See 37 CFR 1.192(c)(7).

(8) Claims Appealed

The copy of the appealed claims contained in the Appendix to the brief is correct.

(9) Prior Art of Record

5,926,726	Bour et al	7-1999
6,017,807	Furukawa et al	1-2000
5,811,319	Koike et al	9-1998
6,100,174	Takatani	8-2000
5,895,223	Peng et al	4-1999
5,789,265	Nitta et al	8-1998

(10) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1, 3-5, 12-30, 31-35 and 42-60 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807).

Bour et al. teaches a carrier gas of H_2 is introduced with reaction gases NH_3 and TMGa and impurity gas Cp_2Mg to a reactor to form a p-type GaN layer at a temperature of 900°C (col 6, 20-26) After formation of the p-type nitride layer the reactant gases are switched out of the reactor and a gas which prevents the decomposition of the III-V layer at such high growth temperatures, NH_3 is added (col 5, ln 60-65 and col 6, ln 31-35). Bour et al also teaches a reactor is cooled down to a temperature where surface decomposition of as-grown p-type GaN layer will not further occur, where upon attainment of the this temperature, the preventer gas, NH_3, is switched out of the reactor and the remaining cool down occurs in molecular N and acceptor activation is preformed either as the reactor is further cooled or maintained at a temperature of

600°C for 20-40 minutes and during the cool down of the reactor a flow of molecular N, N_2, is maintained in the reactor. (col 6, ln 40-65). Bour et al also teaches the anneal process is a quasi-in-situ anneal, where the reactor is brought to room temperature prior to annealing (col 2, ln 32-45) and that ex-situ post-growth anneals have become a common procedure for laser diode processing (col 2, ln 60-64). Bour et al also teaches acceptor activation is the process of atomic H weakly bonded to Mg or Zn dopant atoms are broken by thermal annealing over a period of time (col 6, 7-15) Bour et al also teaches a device which comprises a sapphire substrate upon which is grown a n-type GaN, doped with Si followed by the growth of an active region and is followed by a p-type GaN layer doped with Mg followed by the growth of a cap layer comprising n-type GaN doped with Si (col 8, ln 46-55) Bour et al also teaches that after growth is complete and the reactor cooldown has been accomplished, the n-type cap layer may be removed by etching and the device processed into an operable laser, this reads on applicant's limitation of forming a light emitting diode. Bour et al also discloses the switchout of the NH_3 gas is possible at temperatures as high as the lower end of the growth temperature range for GaN that is around 900°C and maybe higher, with an ambient of N_2 provided in the reactor, activation may be accomplished in a short period of time (col 7, ln 15-40). Bour et al also teaches after the growth of p-type GaN, all reaction gases are switched out of the reactor including NH_3 and immediately after growth dimethylhydrazine is pumped into the reactor and the activation process can be carried out during the cooldown of the reactor, this reads on applicant's substantially preventing hydrogen passivation during the entire cooldown process (col 7, ln 55-67 and col 8, ln 1-30).

Bour et al does not teach the causing of the acceptor doped layer to a p-type layer have a conductivity and a hole density between 3 x 10^{15} cm^{-3} and 1 x 10^{18} cm^{-3} after said cool down process.

In a method of growing p-type gallium nitride, Koike et al. teaches three p-layers of Mg-doped $Al_{x1}Ga_{1-x1}N$ forms a p-layer (61) which acts as a clad layer having a hole concentrations of 5 x $10^{17}/cm^3$, 5 x $10^{17}/cm^3$ and 2 x $10^{17}/cm^3$ and an Mg concentrations of 1 x $10^{20}/cm^3$, 1 x $10^{20}/cm^3$ and 2 x $10^{20}/cm^3$, respectively (col 3, 50-65). Koike also teaches electron rays were uniformly irradiated into the p-layer using a reflective electron beam, where this irradiation changed the p-layer into a p-type conductive semiconductor with a hole concentration of 5 x $10^{17}/cm^3$, 5 x $10^{17}/cm^3$ and 2 x $10^{17}/cm^3$ and a resistivity of 0.5 ohm-cm, 0.8 ohm-cm and 1.5 ohm-cm, respectively (col 5, ln 14-26). Koike et al also teaches forming metal electrode, such as nickel or aluminum, are formed on semiconductor devices utilizing GaN group compounds such as AlGaInN after the semiconductor surface is cleaned by wet chemical etching, utilizing a wet chemical etchant such as buffered hydrogen fluoride (col 1, ln 15-30).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Bour with Koike's electron beam irradiation because it would have produced p-type conductive semiconductors with low resistivities.

Bour et al also does not teach heating said p-type layer to a third temperature greater than the second temperature and less than 625°C.

In a method of forming a P-type GaN compound, note entire reference, Furukawa et al teaches after a p-type gallium nitride compound semiconductor layers formed by chemical vapor deposition, the p-type gallium nitride layers are thermally annealed at more than 400°C and the

p-type impurity can be more effectively activated so that p-type gallium nitride compound semiconductor layers which have fewer crystal defects and lower resistivity can be formed (abstract, col 4, ln 5-67 and col 6, ln 35-60). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Bour et al with Furukawa et al annealing at a temperature greater than 400°C to form a semiconductor layer which has fewer defects and lower resistivity.

Referring to claim 1 and 31, the combination of Bour et al, Koike et al and Furukawa et al teaches the switchout of NH_3 is possible at temperatures as high as the lower end of the growth temperature range for GaN and maybe higher with an ambient of N_2, this reads on applicant's limitation of preventing additional hydrogen from diffusing into the acceptor doped layer substantially throughout the entire cool down process.

Claims 6, 9, 11, 36, 39 and 40-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807) as applied to claim 1, 3-5, 12-30, 31-35 and 42-60 above, and further in view of Takatani (US 6,100,174).

The combination of Bour et al, Furukawa et al and Koike et al teach all of the limitations of claim 6, except chemically etching said surface.

In a method of producing GaN group compound semiconductors, Takatani teaches a p-GaN layer epitaxially grown on a sapphire substrate, with about 10^{19} cm^{-3} of Mg added thereto for providing a carrier density of about 1.5×10^{17} cm^{-3}, where carrier density reads on applicant's term of hole density. Takatani also teaches subjecting the surface of the p-GaN layer to

ultrasonic cleaning in acetone and ethanol, thereby removing the oil present thereon and then immersing in an etchant containing HCl and deionized water for about 3 minutes, thereby removing the adsorbed oxide and then the substrate is immersed in an etchant containing HF and deionized water for about 3 minutes thereby removing impurities adhering to the surface, this reads on applicant's limitation of chemically etching. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the invention taught by the combination of Bour, Furukawa et al and Koike with Takatani's etching because it would have removed impurities and adsorbed oxygen from the substrate.

Referring to claim 9 and 39, Takatani teaches immersing a p-GaN substrate in an etchant containing HCl and deionized water for about 3 minutes, thereby removing the adsorbed oxide and then the substrate is immersed in an etchant containing HF and deionized water for about 3 minutes thereby removing impurities adhering to the surface. This reads on applicant's limitation of chemically cleaning said surface.

Referring to claim 11 and 41, the combination of Bour et al, Furukawa et al and Koike et al teaches all of the limitations of claim 11, except ultrasonically cleaning said surface. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the invention taught by the combination of Bour et al, Furukawa et al and Koike et al with Takatani's ultrasonic cleaning because it would have removed the oil present on the surface of the substrate, which is detrimental to the surface.

Claim 10 and 50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319), Furukawa et al (US 6,017,807) and Takatani

(US 6,100,174) as applied to claims 6, 9, 11, 36, 39 and 41 above, and further in view of Peng et al. (US 5,895,223).

The combination of Bour et al, Koike et al, Furukawa et al and Takatani teach all of the limitations of claim 10, expect the cleaning of said surface comprises cleaning in a solution of KOH, NaOH or NH_4OH.

In a method of etching nitride, Peng et al teaches dipping a nitride chip in an electrolysis liquid and emitting a UV light with a wavelength of 254 nm to illuminate the nitride chip (col 3, ln 40-46), where the electrolysis liquid can be one of KOH as the nitride chip is GaN. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Koike et al, Furukawa et al and Takatani with Peng's because the etching method of Peng offers a finer roughness for an etching surface (col 4, ln 20-24).

Claim 13 and 43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807) as applied to claims 1, 3-5, 12-30, 31-35 and 42-60 above, and further in view of Peng et al. (US 5,895,223).

The combination of Bour et al, Furukawa et al and Koike et al teach all of the limitations of claim 13, expect exposing said surface to electromagnetic radiation.

In a method of etching nitride, Peng et al teaches dipping a nitride chip in an electrolysis liquid and emitting a UV light with a wavelength of 254 nm to illuminate the nitride chip (col 3, ln 40-46), this reads on applicant's limitation of exposing to electromagnetic radiation, where the electrolysis liquid can be one of KOH as the nitride chip is GaN. It would have been obvious to a

person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Koike et al and Furukawa et al with Peng's because the UV light would illuminate the nitride chip.

Claim 7-8 and 37-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807) as applied to claims 1, 3-5, 12-30, 31-35 and 42-60 above, and further in view of Nitta et al (US 5,789,265).

The combination of Bour et al, Furukawa et al and Koike et al teach all of the limitations of claim 7, expect plasma etching said surface.

In a method of manufacturing a blue light emitting diode, Nitta et al. teaches a dry etching method for GaN based semiconductor compounds can be achieved by the plasma etching using BCl_3 and Cl_2, where said GaN based semiconductor comprises p-type $In_xGa_{1-x}N$ (col 4, ln 41-55). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Furukawa et al and Koike et al with Nitta et al because etching rate can be increased and productivity enhanced.

Referring to claim 8, Nitta et al. teaches a dry etching method for GaN based semiconductor compounds, this reads on applicant's limitation of plasma cleaning said surface.

(11) Response to Argument

The Bour et al reference teaches growing a III-V nitride compound semiconductor layer while introducing acceptor impurities into the layer and cooling the acceptor doped layer while

preventing hydrogen from diffusing into the acceptor doped layer by switching out gases which contain hydrogen. The primary difference between Bour et al and the instantly claimed invention is that Bour et al does not teach the heating step after cooling.

Appellants allege Bour et al teaches away from the claimed invention; therefore cannot be combined with Furukawa et al. The Examiner admits Bour et al teaches a preference towards a non-post growth anneal. However, the Examiner maintains that Bour et al simply teaches a post growth anneal is not required and the Bour et al does **not** teach a post growth anneal cannot be preformed. Appellants alleged portion of Bour et al, which teaches away from the combination, column 3, lines 46-50, merely teaches a process that provides acceptor activation with lower processing costs is desirable. The cited portion of Bour et al is strictly limited to providing lower processing costs for acceptor activation only. The teachings of Furukawa et al are directed to an annealing process of a p-type impurity for more effective acceptor activation **and** reducing crystal defects **and** lowering resistivity, note the Abstract of Furukawa et al. The teachings of Furukawa are not limited to acceptor activation, but are also directed to reducing lattice defects in a p-type GaN layer, which is why a person of ordinary skill in the art would be motivated to make the combination. Furukawa et al teaches a method of forming a p-type gallium nitride, which is then thermally anneal at a temperature greater than 400°C while supplying a flow of an inert gas, note claim 1. Furukawa et al also teaches annealing while flowing the inert gas after the GaN compound has been formed causes the activation yield of the p-type impurity to be significantly improved compared to the prior art process where an inert gas is not used and the resulting p-type GaN semiconductor has fewer lattice defects and lower resistivity, note column 12, lines 25-29. As presented in the Final Rejection dated 8/6/2003,

Furukawa et al provides motivation to a person of ordinary skill in the art to anneal a p-type GaN to improve the activation yield **and** to reduce lattice defects and lower resistivity.

In conclusion, Bour et al does **not** exclude the possibility of performing a post-growth annealing, which would be a teaching away. Bour et al merely teaches a post-growth anneal is not required and preference towards not performing a post-growth anneal. Bour et al is solely concerned with acceptor activation, while Furukawa et al is also concerned with reducing lattice defects and lowering resistivity. Appellants have not considered the teachings of Furukawa et al, which provide motivation to one of ordinary skill at the time of the invention to improve the activation yield **and** reduce lattice defects, resulting in a superior product compared to a p-type GaN layer, which is not annealed according to the process taught by Furukawa et al. Economics are a concern in all processes, however obtaining a superior product is a valid motivation for increasing processing costs.

For the above reasons, it is believed that the rejections should be sustained.

Respectfully submitted,

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